

Final Performance Report for NAG5-10381

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This was a project to study the disk and wind of the eclipsing nova-like variable UX UMa, in order to better define the wind geometry of the system, including the nature of the transition region between the disk photosphere and the supersonic wind. We proposed to use phase resolved spectroscopy of the system, taking advantage of the fact that UX UMa is an eclipsing system, to isolate different regions of the wind and to use a Monte Carlo radiative transfer code to simulate the spectra through the eclipse.

In March of 2001, we obtained ~43,000 s of time-tagged FUSE data of UX UMa. The observations spanned several orbits of the binary and, when combined, provide full coverage of the orbit with redundancy (typically, two observations at a given phase). There were no significant anomalies in the data taking process. We completed the data reduction, including reprocessing with the latest versions of the FUSE pipeline, and have spectra at 200 sec (0.012 Porb) time and 0.06 Å spectral resolution that can be binned up to improve S/N for specific tasks.

Qualitative analysis of the data was then performed. The spectra are complex, presumably as a result of the high inclination at which we are observing the disk. Although there are considerable flux variations, the shape of the spectrum seems fairly constant, except during the eclipse. A comparison of the time-averaged spectrum with the eclipse spectrum indicates that the strongest lines, those associated with strong resonance features like OVI, are mainly uneclipsed, and probably originate in an extended wind. There are a host of weaker emission lines that are eclipsed, indicating that they originate near the plane of the accretion disk. For some lines, the eclipsed component is in absorption, which suggests a dense component to the disk chromosphere.

We documented our work in a paper in the *Astrophysical Journal*:

Froning, C. S., Long, K. S. & Knigge, C, 2003, "Accretion and Outflow in Interacting Binary Systems: Far Ultraviolet Spectroscopic Explorer Observations of the Nova-like Cataclysmic Variable UX Ursae Majoris", *ApJ*, 584, 433.

The abstract of that paper summarizes our primary results:

We present far-ultraviolet (905-1182 Å), time-series spectroscopy of the eclipsing, nova-like cataclysmic variable UX UMa acquired with Far Ultraviolet Spectroscopic Explorer (FUSE). The time-averaged spectrum is complex and is dominated by overlapping spectral features. The most prominent features are emission lines of C III, N III, N IV, and O VI. They are broad (FWHM >= 1800 km s⁻¹) and double-peaked, with a central absorption at zero velocity. During eclipse, the spectrum is simpler: the emission lines remain bright, but the absorption components of the lines and the weaker features between the emission lines disappear entirely, leaving a flat continuum. This behavior is also evident in Goddard High-Resolution Spectrograph (1149-1660 Å) spectra that we retrieved from the Hubble Space Telescope (HST) archive. The FUV spectra show flickering on timescales of several minutes. The flickering is seen primarily in the continuum and/or the weaker lines rather than in the prominent emission lines. The orbital light curve has a dip in the FUV flux between orbital phases 0.45-0.65, similar to a pre-eclipse dip detected in HST observations. The equivalent widths of the line absorption features decrease during the dip. We have

detected a systematic wavelength shift of spectral features on the orbital period, but with a phase lag of $\sim 20^\circ$, a phenomenon that has been reported at optical wavelengths. We discuss the implications of our results in the context of models of an accretion disk with a chromosphere between the disk and the extended wind. Finally, we note that the observed FUV flux is too low to be consistent with the temperature and radius of the WD derived in 1995 by Baptista et al., suggesting that their remaining binary parameters, including a mass ratio of 1, ought to be viewed with skepticism.

Based on this, we feel that the project was successfully completed.

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